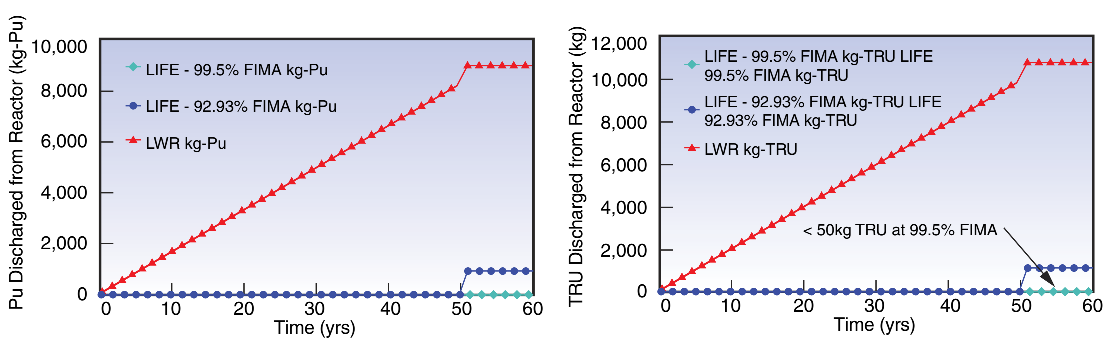
LIFE: Benefits and Challenges

LIFE power plants are well suited to meet the energy challenge facing the planet because they avoid the drawbacks typically associated with conventional nuclear reactors:

- ***LIFE plants are inherently safe.*** Unlike nuclear plants that use a self-sustaining chain reaction to produce energy, LIFE's design requires firing the laser to trigger the pulsed release of neutrons that drives a pulsed fission response. Because the fission blanket is always subcritical, and decay heat removal is possible via passive mechanisms, LIFE is inherently safe. No runaway reactions are possible.
- ***LIFE is proliferation resistant.*** Proliferation risk, the chance that fuel destined for a nuclear power plant could be diverted for weapons purposes, is virtually eliminated with fuel for a LIFE engine. Fuel processing before and after use in a conventional nuclear power plant creates the two biggest proliferation worries. Before use, the fuel is enriched to yield a more concentrated form. That same enrichment process can, and has been, used to make weapons-grade uranium for nuclear weapons. After use, some countries reprocess fuel to recover the unused material still in the fuel rods. This can lead to proliferation because it can make weapons-grade plutonium accessible.

  By integrating fuel generation, energy production and waste minimization into a single device, the LIFE engine requires neither enrichment nor reprocessing, and there is no need to remove fuel or fissile material generated in the reactor. LIFE engines can use fuels without prior enrichment and then burn them so completely that virtually no weapons-attractive material remains at the end of a plant's life. When compared with existing and other proposed nuclear reactor designs, the LIFE engine exceeds alternative reactor designs in the most important measures of proliferation resistance.
- ***LIFE can reduce the world's hazardous nuclear material.*** In addition to burning natural uranium, a LIFE engine can use for its fuel the two waste streams generated by LWRs – spent nuclear fuel (SNF) and depleted uranium (DU) left over from the process used to enrich uranium. If the United States builds a reprocessing facility, as proposed for the Global Nuclear Energy Partnership (GNEP), LIFE engines could also burn as fuel a mixture of plutonium and minor actinides – the highly toxic, long-lived radioactive material contained in spent nuclear fuel that would be isolated from SNF by reprocessing. Unlike fast nuclear reactor technologies, LIFE could burn all of the high-level waste with a single reprocessing step. Moreover, LIFE power plants could burn existing stocks of high-level waste as well as waste that will be created in the future.
- ***LIFE reduces the need for geologic waste repositories.*** The waste from electricity already generated by past and existing nuclear power plants is almost all in temporary storage facilities. If this existing waste is reprocessed and sent to a long-term geological storage facility such as Yucca Mountain, the proposed repository in Nevada, the repository would



LIFE Waste Discharges

LIFE's more complete burn discharges far less plutonium per reactor than a typical light water reactor (LWR). LIFE also generates less transuranic waste (TRU) per reactor than an LWR (FIMA: fission of initial metal atoms).

LIFE BENEFITS

be nearly full. LIFE offers a way to "burn to a nuclear crisp" much of the SNF now destined for transportation to and storage in a Yucca-Mountain-type repository, as well as DU that exists now and will be created in the decades ahead.

- ***LIFE is extremely efficient.*** The LIFE engine extracts more than 99 percent of the energy content of its fuel, compared to less than 1 percent of the energy in the ore required to make fuel for a typical LWR. Higher fuel utilization means that far less fuel is required to generate the same amount of energy. A 1,500-megawatt LIFE power plant could operate for 50 years on only a small roomful of fuel. A carbon-free LIFE engine can produce very hot helium at utility scale to drive the turbines that generate electricity in the same way as in existing coal, gas and nuclear power plants. Thus a new or refurbished conventional-to-LIFE power plant can blend seamlessly into the existing energy infrastructure.

Meeting the Technical Challenges

A number of technical challenges must be overcome along the path to commercial LIFE engines by the year 2030. The key issues in the development of a LIFE engine are:

- ***Achieving robust fusion ignition and burn on the National Ignition Facility (NIF).*** Initial experiments on NIF began in 2009, with the first attempts at achieving thermonuclear fusion in 2010. Success at NIF will pave the way for development of the fusion "front end" of the LIFE engine.
- ***Development of a high-repetition-rate laser fusion driver.*** NIF will execute one laser shot every few hours. A LIFE engine needs to execute 10 to 15 shots per second. To achieve this high repetition rate, the LIFE fusion driver will need to use diode-pumped solid-state lasers (DPSSLs) instead of the flashlamp-driven lasers used in NIF. Experts predict that the cost of the diodes used in DPSSLs will continue to decrease significantly over the next several years, and many technologies required for DPSSLs have been demonstrated with the Mercury laser system at LLNL.
- ***Inexpensive fusion targets.*** LIFE engines will require several hundred million low-cost targets per year. The targets must be injected into the center of the LIFE chamber at a rate of 10 to 15 per second. Progress in the development of the technologies required to manufacture these targets has been made at General Atomics (GA) in San Diego, CA, as well as at Livermore. Livermore and GA materials science experts believe technologies for low-cost, large-volume target manufacturing can be adopted from other industries.
- ***Fission fuel and issues associated with the operation of the fission engine.*** The first wall, or innermost shell, of the fission blanket will be exposed to large fluxes of fast neutrons and X-rays. Ongoing research in Japan, the European Community and the United States is focused on developing new structural steels that are suitable for both fusion and fission reactors and also the LIFE engine environment. Researchers are also investigating and producing new forms of fission fuel capable of withstanding extreme environments for increasingly longer periods. Fissile material burn fractions as high as 85 percent have already been achieved in the kind of pellet fuel form required for a LIFE engine burning highly enriched fissile fuel or plutonium.